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Reclamation era

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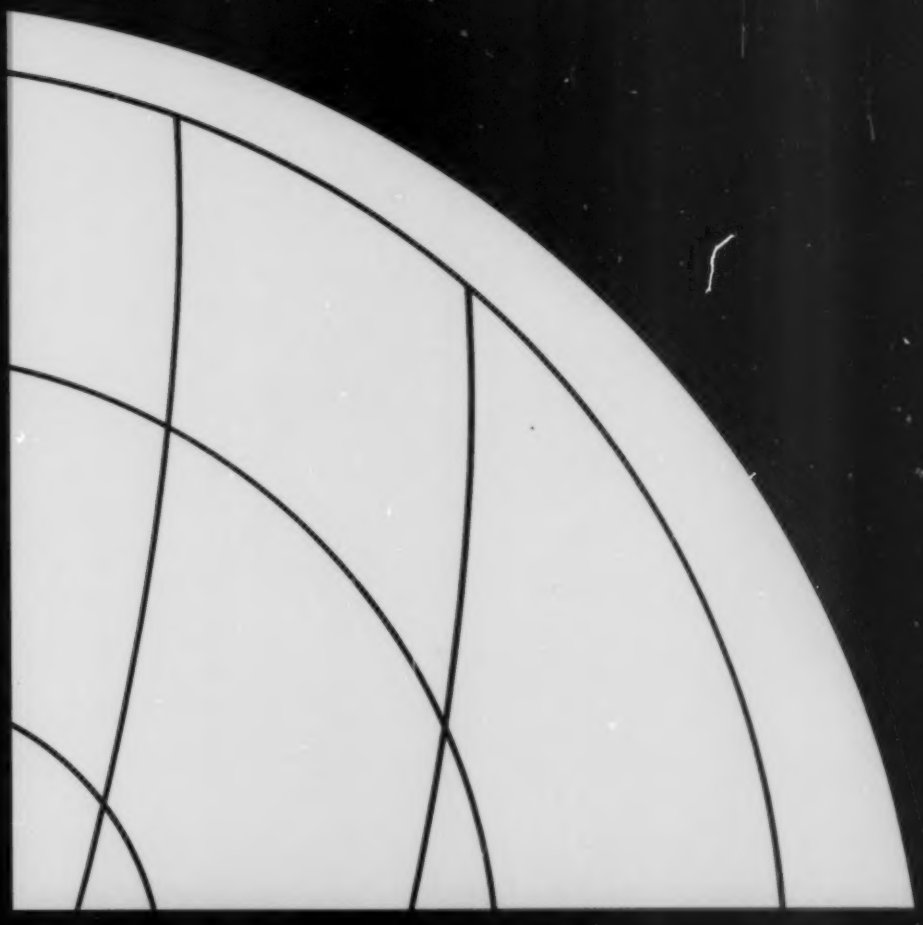
Dam Safety



Reclamation

era

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Cecil D. Andrus, Secretary
Bureau of Reclamation
R. Keith Higginson
Commissioner

Editor
Carol A. White

Inquiries should be addressed to: Editor, *Reclamation Era*, Bureau of Reclamation, Code 140, Bldg. 67, P.O. Box 25007, Denver Federal Center, Denver, CO 80225.

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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

Dam Safety Program

A Model for Other Federal Agencies

by Dave Prosser and Fred Gientke

Over the last 20 years, there have been a number of catastrophic dam failures around the world—failures generated by a variety of reasons including faulty design, engineering mechanics, tectonic, and geotechnologic problems. As an example, the foundation of the double arch of Montpassant Dam in southern France appears to have literally exploded from excessive water pressure in the foundation. A major portion of the reservoir behind Vaiont Dam in Italy was impelled over the dam by a massive landslide into the reservoir. Reclamation's Teton Dam in Idaho failed as a result of inadequate protection of the impervious core material from internal erosion. Portions of the embankment of Kelley Barnes Dam near Toccoa, Ga., failed by piping and sloughing within the embankment, releasing a devastating torrent against an unsuspecting bible college downstream.

Regrettably, dam failures have

Dave Prosser and Fred Gientke, Division of Dam Safety, Washington, D.C.

occurred repeatedly and regularly, both within and without the United States. Recognizing the tremendous hazard involved, engineers and geotechnologists strive to ensure structural integrity through high standards and recognition of site-specific geologic, hydrologic, seismic and geotechnologic conditions. The major Federal dam building organizations in the United States: the Corps of Engineers, Tennessee Valley Authority, and Bureau of Reclamation, have long recognized this requirement and have sought to develop state-of-the-art technology in these critical areas. Improvement in dam engineering is a continuing goal of these agencies.

Likewise, several States have established effective and aggressive safety of dams programs. They include Idaho (which has had legislation enacted since 1895), Tennessee, Arizona, and California. California has significantly broadened its powers in light of four major failures this century—St. Francis Dam (landslide), Baldwin Hills (foundation displacement), Van Norman Dam (earthquake)—all in southern California, and Hell Hole (overtopping of a partially completed embankment). Today, California and the other three States are considered models for the remaining States.

Historically, public interest in dam safety and legislative and administrative reaction have been intensified immediately following a dam failure having serious consequences. For example, in 1972, a coal waste embankment was breached on Buffalo Creek in West Virginia. Congressional hearings quickly developed and the National Program of Inspection of Dams, PL 92-367, was enacted that year. The act directed the Corps of Engineers to inspect and inventory all non-federal dams exceeding 25 feet in height or storing more than 50 acre-feet of water. This was no small task as more than 50,000 structures were eventually cataloged.

States inspecting non-Federal dams

However, that program was inadequately funded and the Corps was not authorized or empowered to repair dams found to be hazardous. Further, many owners of private high-risk dams were reluctant to implement remedial measures due to high costs involved.

A second round of investigations and State and Federal hearings followed the failure of Teton Dam in 1976 and the Kelley Barnes Dam in 1977.

Arising from those hearings, indications were that the States are accepting the responsibility for inspection of non-Federal dams, and they are being encouraged to provide long-term regulation to both existing and new private dams.

At the Federal level, President Carter in April 1977, directed the head of each Federal agency involved with dams to perform a review of agency activities related to dam safety. The Chairman, Federal Coordinating Council for Science, Engineering and Technology (FCCSET), was directed to coordinate the dam safety review and to seek commonality and consistency as appropriate, and to provide recommendations as to the means for improving the effectiveness of the government-wide dam safety program. The memorandum instructed the Office of Science and Technology Policy (OSTP) to review agency regulations, procedures, and practices, and to have a panel of recognized experts conduct a review of the proposed FCCSET federal dam safety guidelines. The individual agency reports, the FCCSET report, and the OSTP review have been completed. The guidelines are expected to be issued soon.

In addition the General Accounting Office (GAO) has conducted an inquiry into the "slow progress in developing and implementing a national dam safety program." The reviews by FCCSET, OSTP, and GAO, contain far-reaching recommendations which to a large degree were implemented or are being considered for implementation by Reclamation as well as other Federal agencies.

The Bureau of Reclamation has historically recognized the need for a dam safety program for existing dams, having instituted a biennial Review of Maintenance Program (ROM) in 1948. Later, the Bureau's concern over structural integrity was expanded with the introduction of the Examination of Existing Structures (EES) in 1965 to specifically review the hydrologic and, later, the seismic adequacy of structures in light of recent natural events and technological improvements in these disciplines since the structures were built.

Reclamation openly accepted reviews

Teton Dam, of course, never came under either the ROM or the EES program; it failed before it was completed and transferred from construction to operational status.

Immediately after the failure of Teton, the Bureau of Reclamation and the Department of the Interior initiated a series of reviews and investigations into Reclamation's internal procedures and the cause of the failure of the dam.

The Department released two reports in 1977. The first report was specifically concerned with the causes of the Teton Dam failure, whereas the second focused on reviewing Reclamation's procedures and practices related to dam safety that were in need of strengthening. Over 80 policy recommendations relating to management or technologic concerns resulted from the latter report, and at this date many of those recommendations have been adopted by Reclamation.

Also in 1976 and 1977, external investigations into Reclamation's procedures were conducted to consider the management and technologic aspects of the Bureau's Plan-Design-Construct-Operate-Maintain (PDCOM) process for dams. The first, "The Failure of Teton Dam" was published in December 1976 by the Independent Panel to Review Causes of Failure of Teton Dam.

In early 1977 the firm of W. A. Wahler and Associates was engaged to conduct an emergency study of seven recently completed Reclamation dams, namely Crystal, Mt. Elbert, and Pueblo, all in Colorado; Mountain Park, Oklahoma; Nambe Falls, New Mexico; Ririe, Idaho, and Soldier Creek, Utah. These newly constructed dams were in various stages of filling and were reviewed to determine if there were any areas of apparent concern.

Later that same year, the National Research Council, under contract with the Department of the Interior, reported on the "Review of the Program of the U.S. Bureau of Reclamation for the Safety of Existing Dams."

More recently, a report was prepared by the firm of Tibbetts-Abbett-McCarthy-Stratton (TAMS)—"an assessment of technical procedures and safety

standards for water storage dams." The report presents over 170 recommendations in the dam design, construction, and operation area. The recommendations are currently under review and many will be implemented by the Bureau of Reclamation.

Concurrent with the development of the above reports, Reclamation accelerated certain activities within the Examination of Existing Structures program to formalize and strengthen examination criteria and to provide for remedial corrective work for major Reclamation facilities under a Safety Evaluation of Existing Dams (SEED) Program.

Nine reports— 250 recommendations

Few organizations have been subjected to the number of searching reviews Reclamation openly accepted and experienced in the last 2 years, both internal and external, from public and private sectors, and encompassing technological and managerial extremes. The results are extensive and far reaching, and include a major reorganization, reappraisal of existing technology, and institution of numerous new managerial controls within the organization.

Out of these nine reports came over 250 recommendations, some mutually supportive and many in advanced stages of implementation.

A Division of Dam Safety was established in late 1978. Although specific "line function" offices were assigned implementation responsibility, the consolidation, coordination, and evaluation of these safety recommendations are the organizational responsibility of the Director, Office of Dam Safety, Engineering and Science. The Dam Safety office consists of two segments: the Washington D.C. - based division office for policy and program formulation and accountability functions, and a Denver-based Dam Safety Operations Office to implement technical, site-specific evaluation and oversight activities.

As recommended in the numerous reports, the Office of Dam Safety reports directly to the Commissioner to assure high-level program compliance.

The Washington office prepares related legislation, reviews priorities for safety related structural modification of dams, and evaluates dam safety related programs of other Reclamation offices, such as the ROM and SEED programs. The Division of Dam Safety has the responsibility for periodic review

of the PDCOM process, for contracting with consultant or engineering firms for program, project, and structural reviews, for inspections, and for analyzing and interpreting performance data. Several final responsibilities include review of the adequacy of emergency preparedness plans as well as the initial filling operation of newly constructed dams.

The Denver-based Dam Safety Operations Office formulates the technical review standards and guidelines for the division within the PDCOM areas. Compliance to these review standards and guidelines is also a part of its responsibility along with site visits to Reclamation structures to review the adequacy of maintenance and safety evaluation of existing dams programs.

Reclamation dams examined at 2-year intervals

Out of all the reviews issues a single dominant theme—positive change for safety of dams in Reclamation. In particular, there has been a change through intensification and emphasis on existing programs, a change through the introduction of new technology, and a change through reorganization.

Within existing programs such as ROM, greater emphasis is being placed on factors affecting dam safety during the biennial maintenance reviews. Under this program, each Reclamation dam is examined by project and regional personnel at 2-year intervals, depending on the nature of the facility. Specialists from Reclamation's Engineering and Research Center in Denver participate in the review of each dam at least once every 6 years.

A formal report on the condition of each dam and of its appurtenant structures, including recommended corrective actions, if any, is prepared after the examination and becomes a part of the permanent history of the dam's performance.

As the engineering profession develops new criteria and technology for the design of dams, it becomes necessary to reevaluate the safety of the older dams. Accordingly, the Examination of Existing Structures Program was initiated to evaluate the ability of Reclamation's older dams to withstand safely the currently estimated maximum probable flood and to prescribe corrective action necessary to ensure the safety of the dams.

Initially, the Examination of Existing Structures Program focused on structural and hydrological aspects of the dams where new methodology for estimated floodflows made the review necessary. Later, however, the scope of the program was enlarged to include new methodologies for evaluating the response of dams to earthquakes, the effect of potential landslides, and a review of the condition of upstream dams.

Under the Examination of Existing Structures Program, a formal report is prepared for each structure which the review identifies as having significant deficiencies. The report includes information on the need for structural modification, the hazards to the public, the recommended corrective action and the alternatives thereto, the environmental impacts, and the repayment ability of the water users. The completed reports are used as a basis for recommending corrective action and, in some cases, requesting congressional authorization.

Safety of Dams Act, Public Law 95-578

As part of the EES program existing or potential landslides in and about Reclamation reservoirs and structures are identified and cataloged. Information collected in the field is assembled and later transmitted to the E&R Center for analysis and report preparation.

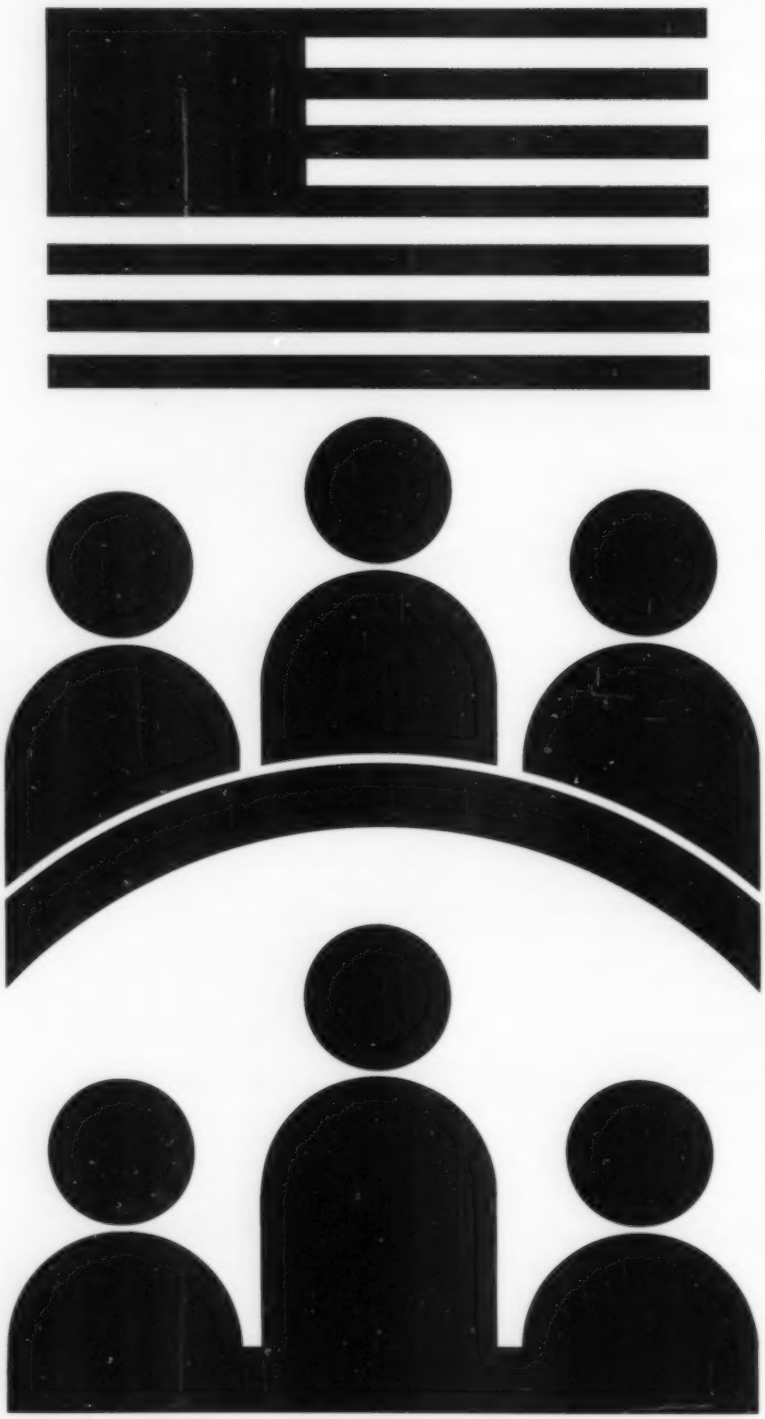
Following Teton, several important aspects of the safety inspection activity were intensified and the resultant program became known as the Safety Evaluation of Existing Dams Program (SEED). The Bureau has allocated an enormous amount of manpower to this intensified effort and five to seven dams per month are being reevaluated.

Preliminary to the onsite examination, the SEED team prepares an exhaustive data book which provides, in one source, information on the geology, hydrology, foundation and structural considerations, instrumentation, operating procedures,

and past performance of the dam. The results of this intensive survey are prepared along with observations, conclusions, and recommendations for any further action needed in the event of any detected deficiencies.

If a deficiency is detected and remedial action is required, the work is programmed for accomplishment. Regional Directors are requested to budget for the cost of modification, and the Division of Design, E&R Center, Denver, prepares plans and specifications. The identification of the need for all proposed safety of dams modification work performed pursuant to the Reclamation Safety of Dams Act of 1978 is the responsibility of the Assistant Commissioner - Engineering and Research, in consultation with the appropriate Regional Director. He is also responsible for the preparation of all design drawings, cost estimates, and construction specifications. Regional Directors continue to be responsible for annual programming and budgeting and performing delegated work, and environmental compliance activities; also for negotiating and administering any water-user contracts necessary for reimbursement and/or operation and maintenance of the modified facility.

The Reclamation Safety of Dams Act provides non-reimbursable authority for Reclamation to proceed with modifications if the need is based upon new technology or inadequate design. The Act itself (Public Law 95-578) makes $100 million available for appropriation for corrective modification of dams. Specifically, it allows the Secretary of the Interior to construct, restore, operate, and maintain

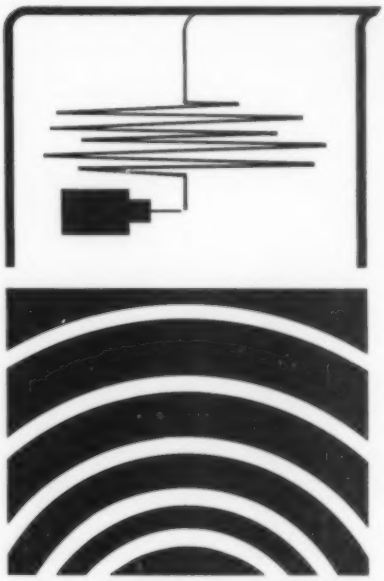


new or modified features at existing Reclamation dams for safety of dams purposes. Work performed pursuant to the act must be for safety of dams purposes and not for the specific purpose of providing additional conservation storage capacity, or developing benefits over and above those provided by original project authorization and its amendments. The act further stipulates that any deficiencies resulting from age, normal deterioration, or nonperformance of maintenance shall be project costs.

Prior to initiation of actual construction work, a modification report for each dam is presented to the Congress for acceptance within 60 session-days. The report includes an assessment of environmental impacts of the proposed work, the extent and cost of the work, and the alternatives considered.

Dam Safety Office cited as model

The attention given to dam safety in Reclamation has intensified during the past 18 months. In compliance with President Carter's April 1977 message for an evaluation of dam safety procedures and practices within Federal agencies, Commissioner of Reclamation R. Keith Higginson has instituted and wholeheartedly endorsed an aggressive and accelerated program. Major recommendations of various reviews have been adopted in addition to those discussed earlier:



- A review of dam instrumentation technology as well as the level of instrumentation at existing sites is underway;
- External reviews of dam design and construction processes have been established as Reclamation policy;
- The development of a research program for evaluating the risks and probability of failure of proposed dams is being considered;
- The adoption or development of new technology particularly in the embankment, geotechnic and instrumentation capabilities within Reclamation is being emphasized;
- Stronger emergency preparedness plans and an active public participation program in all phases of dam building and operation are in the process of development;
- Memorandums of understanding with the Reclamation States, broadening their participation role in the project development, have been executed;
- Design engineer and geologist site reviews at all important design and construction phases are now Bureau policy;
- Regular, professional surveillance, with the aid of instrumentation and quick communication channels, is under development;
- Elaborate design and operation documentation standards have been prepared and are under constant review.

The Office of Science and Technology Policy (OSTP) report on the review of Federal dam building agency regulations, procedures and practices released early this year lauded the Bureau of Reclamation for its new emphasis on dam safety.

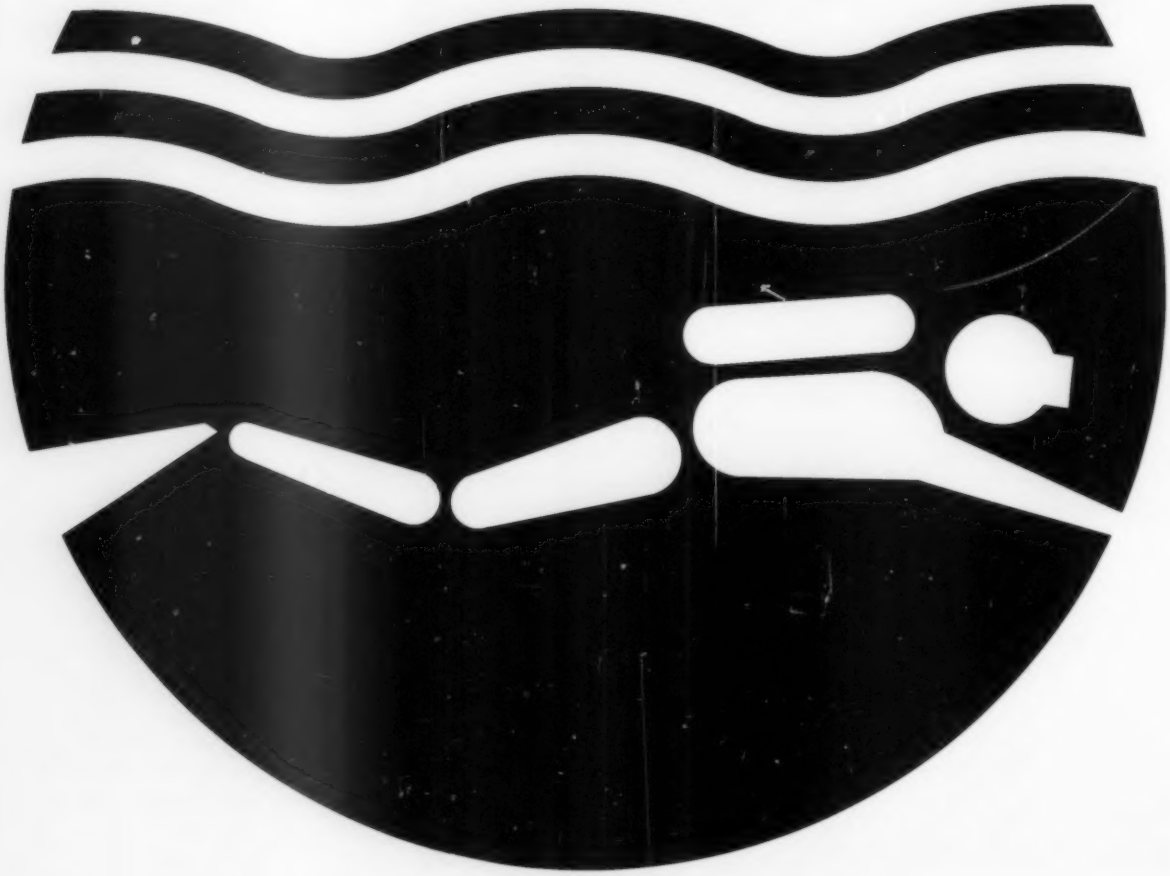
"Such an office (as established by Reclamation)," the OSTP report stated, "can be the most effective single action for an aggressive dam safety program—free of the mission-oriented pressures felt by the design, construction and operations office."

As structured, Reclamation's dam safety office should serve as a model for other Federal agencies with dam responsibilities.

Reclamation's SCUBA DIVERS

A Money Saving Asset

by Sue DeShazo



Jerry Garner (l.) and Bill Karsell (r.) prepare for inspection of stilling basin at Crystal Dam.

Buoyancy ... decompression ... "C" card ... bends. If these terms are not familiar to you, you are not one of the more than 30 Reclamation employees who have been trained as SCUBA divers.

You may not know that the word "SCUBA" was coined to describe the Self-Contained Underwater Breathing Apparatus, which is a portable air tank strapped to the back with breathing regulator allowing a human to remain underwater for an extended period of time.

The Reclamation employees who have been trained as SCUBA divers are engineers, biologists, geologists, environmentalists, economists, technicians, and an archeologist, but diving is a voluntary part of their jobs.

Sue DeShazo, Public Information Specialist, Southwest Region, Amarillo, Tex.

Photographs by Vern Jetley, photographer, Upper Colorado Region; Lee Nielsen, photographer, Southwest Region; Gene Hertzog, photographer Lower Colorado Region; Tom Spicher,regional dive team leader, Grand Coulee, Wash.

They are members of SCUBA diving teams based in five of the seven Reclamation regions: Pacific Northwest, Boise, Id.; Mid-Pacific, Sacramento, Calif.; Lower Colorado, Boulder City, Nev.; Southwest, Amarillo, Tex.; Lower Missouri, Denver, Colo.

The first Bureau of Reclamation SCUBA diving team was formed in 1964 in Sacramento, Calif., to fulfill the need to determine the condition of underwater structures. The Mid-Pacific Region first hired commercial divers, but soon realized the divers did not have the technical knowledge to describe precisely what they viewed while underwater. As a result, some Reclamation professionals were trained as SCUBA divers and now use their expertise underwater.

Many other aspects of the Reclamation program are now enhanced by using diving teams. In addition to the original need to examine, survey, and report the condition of submerged structures, the program has been expanded to include investigations for environmental and geological conditions, biological and fishery research, and aquatic weed control, as well as emergency evaluations of facilities.

First diving team formed in 1964

Reclamation divers must be trained and certified for SCUBA diving, be in top physical condition, and have a stable mental attitude with the ability to perform well under heavy stress. They receive comprehensive physical examinations annually. Periodic retraining, including training in first-aid and cardiopulmonary resuscitation (CPR), is

required. Bureau divers must also maintain proficiency by logging at least one dive every quarter, and each year must demonstrate a minimum level of endurance by making a surface swim of 800 meters (approximately 875 yards) in full gear weighing almost 80 lbs., in 30 minutes or less.

Before being accepted into a basic SCUBA diving certification class, potential divers must be "comfortable" in the water and capable of meeting the physical demands a diver encounters. To achieve basic certification, 20 to 22 hours of classroom work, 20 to 22 hours of training in a pool, and at least three dives in open water must be satisfactorily completed. Upon completion, the divers are issued a certification card. This "C" card is required and must be presented at commercial establishments in order to have air tanks refilled. In some areas the "C" card must be shown to rent equipment.

Basic certifications are recognized from national organizations such as Young Men's Christian Association (YMCA), National Association of Underwater Instructors, Professional Association of Diving Instructors, and SCUBA Schools International. Several other certifications, including advanced diving, divemaster, instructor, and underwater photographer, are also offered by these organizations. The majority of Reclamation divers hold at least one other certification beyond the basic.

At least one dive every quarter

In an effort to standardize diving regulations throughout the Bureau of Reclamation, the five regions having dive teams developed a basic set of regulations. These regulations were reviewed by the Divisions of Safety, and Operation and Maintenance (O&M) Technical Services at the Engineering and Research Center (E&R Center) in Denver, and have been approved by the Commissioner of Reclamation. The regulations will be evaluated for one year prior to incorporating them into the *Reclamation Instructions*.

Darrell Temple has been named Bureau-wide chairman of the Diving Advisory Committee. Dick Crysdale is his alternate. Both Temple and Crysdale are former divers, and are in the O&M Technical Services Division at the E&R Center in Denver. Other members include R. J. Searle, Chief, Division of Safety, E&R Center, and the Regional Dive Team Leaders. This committee, under the direction of the Assistant Commissioner for Planning and Operations Clifford Barrett and Chief, O&M Technical Services Ben Prichard, is responsible for the overall policy and guidelines for the Reclamation SCUBA diving program.

(Left to right:) Jerry Moore, David Allen, Bill Karsell, Ray Nelson, and Cherry Beasley inspect gear.

Divers learn water entry.

The Regional Diving Advisory Committee will continue to administer the program within each region. In most instances, the regional committees are composed of the safety officer, the dive team leader, and representatives from the water and land, power, design and construction, and administrative divisions. Written authorization is required prior to each dive. The request is submitted to and approved by the advisory committee.

Team members emphasize that working dives at Reclamation facilities are totally different from sport dives. Sport dive conditions are usually near ideal, such as Pacific and Caribbean excursions—a window to beautiful coral and marine life in warm waters.

Diving at Reclamation facilities can be just the opposite. Visibility less than 3 feet is often encountered in reservoirs and stilling basis. Water temperatures as low as 32°F., high wave action, and fast water are frequently encountered. Divers work within the underwater confine-

A diving team consisting of members from LC, SW, and LM Regions work together at Crystal Dam.

ment of structures, as well as difficult entrances to and exits from the water. Many times it is necessary to "gear up" at the water's edge after handcarrying all equipment across rugged terrain to the dive site.

In addition to the wet suit and air tank, the diver's gear includes a mask, snorkel, fins, air regulator, submersible tank pressure gage, a buoyancy compensator (a vest that can be inflated and deflated to help the diver maintain his position underwater), weight belts, depth gage, watch, compass, and knife.

Equipment varies from region to region, including vans designed specifically to carry team members and their gear, underwater still and video cameras, boats, dive flags, diver propulsion vehicles called SCUBA scooters, air compressors, underwater lanterns, and even an air storage tank and repair shop.

Reclamation divers use the "buddy" system. They must remain in constant contact with their diving partner, even if that means a tether in low-visibility waters. Also, a safety diver is

Max Groom prepares an underwater video camera for a dive at Crystal Dam.

always suited-up on the surface during any diving operation.

Reclamation diving operations are limited to depths that will not require decompression. This minimizes the danger of decompression sickness, commonly known as the bends, which is the formation of air bubbles in the blood stream and body tissues. Diving operations are

Majority hold certifications beyond basic

limited to 100-foot depths that vary with altitude. Dive tables and altitude conversion tables are constantly used to prevent physical problems associated with high-altitude diving. For example, 80 feet of actual depth at an altitude of 6,000 feet would be equal to 100 feet at sea level. The depth and altitude ultimately determine how long a diver can remain underwater without making decompression stops during the ascent to the surface.

All Reclamation divers agree that preparation time in planning a dive should and usually does exceed the execution time. Once in the water, concentration is a major factor, and concentration becomes more difficult with increased depth, coldness of the water, and body fatigue.

Team Leader in the Mid-Pacific Region where the first Reclamation SCUBA dive team was formed, is Larry Boll, a mechanical engineer in the Division of Water and Power Resources Management. Other team members are:

Jim Andrews, Regional Engineer—one of the original members of the 1964 team who is still an active diver;

Ernie Lendenmann, a geologist in the Division of Design and Construction;

Don Nelson, a civil engineer in the Auburn Construction Office, Auburn, Calif.;

Dave Poore, a mechanical engineer in the Folsom Construction Office, Folsom, Calif.;

Rich Kristof, a civil engineer in the Central Valley Coordinating Office, Sacramento.

MP Region—first dive team

The Mid-Pacific team does most of its diving in reservoirs, stilling basins, and large canals. The most difficult assignments are in siphons where divers must swim horizontally through a tunnel for several hundred feet.

Team Leader Boll particularly remembers a dive at Klamath Falls in Oregon in late April one year when an unexpected late winter storm dumped 6 inches of

snow. He describes it as "diving all day in a raging blizzard. We weren't sure if we were colder in or out of the water."

The Pacific Northwest Region organized its team in 1966 in Ephrata, Wash. One year later the team's home base was moved to Grand Coulee. Team Leader is Tom Spicher, a mechanical engineer at Grand Coulee. He is a charter member of the first Reclamation team formed in Sacramento.

Other team members based at Grand Coulee are Phil Hansen, a geologist; Joe Bailey, a geologist; and Ron McKown, an environmentalist.

The remaining team members hold positions in the regional office in Boise. They include: Brent Carter, Regional Geologist; Max Van Den Berg, a civil engineer; Dan Tomich, a civil engineer; Dan Wilson, a mechanical engineer; and Jim Doty, a civil engineer.

The Pacific Northwest Region team members boast that they have some of the "best water conditions" of any Reclamation region. They point to Cle Elum, Kachess, and Keechelus Lakes in the Cascade Mountains where visibility ranges up to 200 feet. However, not all is ideal. They can also point to a dive in 32°F. water with an air temperature of 10°F., in the fast waters of the Columbia River.

Divers use buddy system

The Lower Missouri Region, with headquarters in Denver, was the third region to determine a need for underwater observers, and that team was started in 1968. This team specializes in high-altitude diving. Most of the facilities and reservoirs in this region are in the Rocky Mountains and altitudes of 9,000 feet are common.

At present the team has three members: Doug Eller, a computer specialist and Team Leader; Russ Smith, a civil engineer; and Les Haussler, an economist. Five new members have been selected and are being trained. Tom Lincoln, the first Reclamation archeologist to volunteer for diving duties, is one of the five new members.

Like most divers, they have discovered "sunken treasure." Not long ago they found a small fishing boat on the bottom during an inspection of Olympus Dam. Since it posed a possible hazard to the gates, the divers tied a rope to the sunken boat and workers on surface brought it to the top.

The largest team is in the Lower Colorado Region, headquartered in Boulder City, Nev. The team consists of 10 members and is now recruiting for two more. The original team was trained in 1969 and put into operation in early 1970. This team has the only full-time diver. He is Team Leader Max Groom. Groom is a Marine Operations Specialist. In addition to being a professional diver, Groom is a

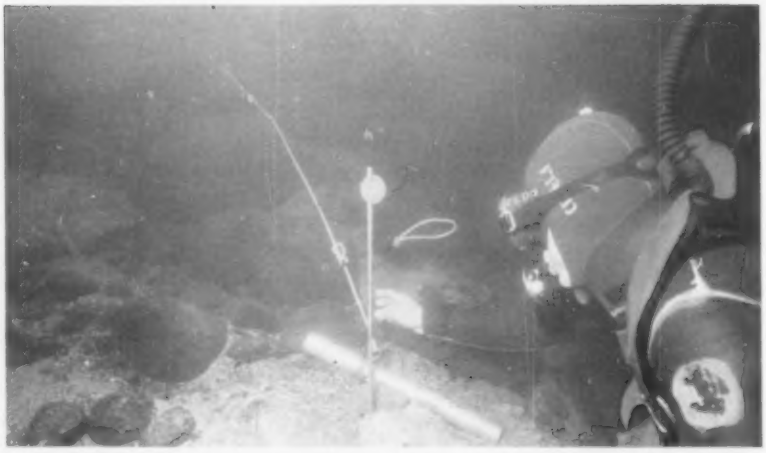
Divers in the Columbia River inspect conditions downstream from Grand Coulee Dam.

certified SCUBA instructor and teaches at the University of Nevada at Las Vegas. He is also certified to repair equipment. The Lower Colorado Region is the only Reclamation region that has a complete repair station, as well as the largest air storage bank in the State of Nevada.

The Lower Colorado diving team boasts a full complement of photography equipment and is the proud possessor of three "SCUBA scooters" (diver propulsion vehicles) which aid divers swimming against strong currents and reduce fatigue during long periods in the water.

Others on the team are: Dave Branstetter, a geologist; Dean Johanson, a civil engineer; Howard Carver, a hydrology technician; Frank Hunter, a civil engineer; Wayne Deason, an environmentalist; Jerry Garner, a civil engineer; Gary Bryant, a biologist; William Butler, a biologist; Harold Lawson, a property specialist.

One of the most unusual dives the team makes is the examination of turbines at Hoover Dam. Team members dive into the tur-



bine itself to examine the four-ton defuser cone. This cone smooths the turbulence in water coming from the turbine and prevents aeration in the water below the dam. Defuser cones sometimes break loose dropping about 55 feet into the tail race. The divers retrieve the cones, and they are rebuilt and reinstalled without moving the generator.

SW Region— only female diver

Diving team activities have cut a $1-million operation to less than $2,000. The operation has been performed four times over the last 6 years.

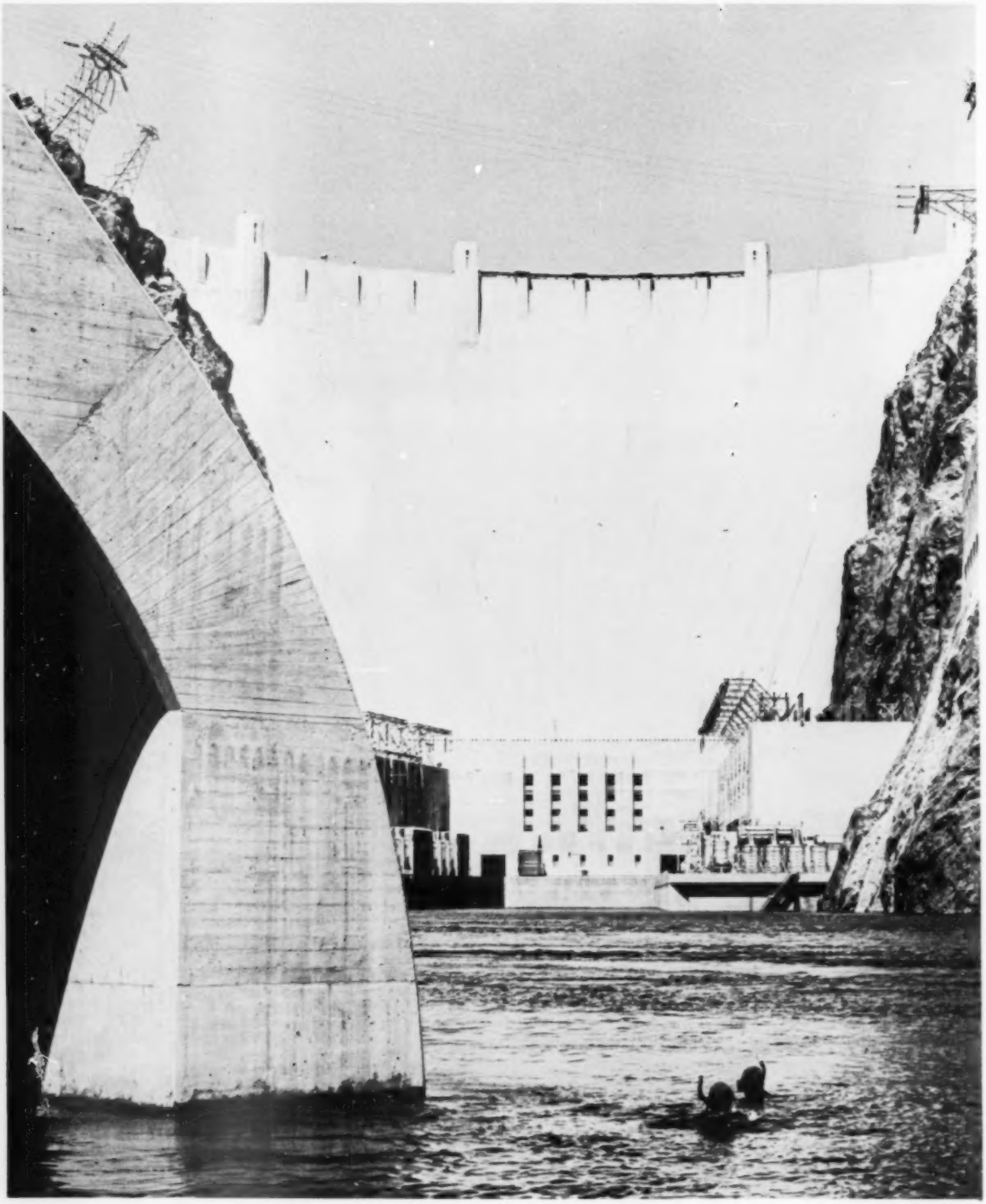
During the first 18 months after the Lower Colorado team began diving, its members logged over 2,000 hours of "bottom time" (the span of time from when the diver leaves the surface until he begins his ascent). They logged this time during the inspection of the construction progress on the Lake Mead entrance to a large tunnel being drilled to furnish a domestic water supply to Las Vegas as part of the Southern Nevada Project.

The newest team is located in the Southwest Region, headquartered in Amarillo, Tex. The team was organized in 1970, and has the first and only female diver in the Bureau of Reclamation. Cherry Beasley, a records and reports clerk, has been an active diver for 4 years. Team Leader in the Southwest Region is Ray Nelson, a civil engineer. Other team members include: David Allen, a civil engineer; Jerry Moore, a civil engineer; Bob Karrh, a civil engineer; and Bill Karsell, a biologist and assistant team leader.

Jerry Moore is a certified underwater photographer and a certified instructor. He teaches SCUBA diving at Amarillo College and West Texas State University. Both Moore and Groom of the Lower Colorado Region are working toward certification as master instructor through the Professional Association of Diving Instructors. The master instructor certification is the highest designation available to SCUBA divers.

LM Region— high altitude diving

One of the most challenging dives for the Southwest team was at Sanford Dam on the Canadian River Project in Texas. The divers had to be lowered by "basket" inside the intake tower trashrack to begin their underwater evaluation of the dam. Once inside the gratings, the divers examined gate guides by swimming into and out of the trilevel gates on the intake tower. The team also has assisted in recovering items while diving, including stolen guns and a motorcycle.



Concrete examination at Hoover Dam near overflow portals.

During the fall of 1978, team members from Lower Colorado, Southwest, and Lower Missouri Regions got together to perform the first joint inspection of a Reclamation structure. Subject of the investigation was the stilling basin at Crystal Dam in Colorado. The divers were checking for the presence of construction debris and damage from turbulent water due to normal operations of the dam.

The boat and equipment used by the divers had to be lowered into the water by a crane. The three-region venture included an experiment with an underwater video camera which was connected to a monitor that could be viewed in an office trailer in a parking area. This video tape enabled the project engineers to observe the condition of the basin and the dam. It is also a permanent record which can be used for future reference and dive orientations.

Crystal Dam is at an elevation of 6,772 feet and the divers had to work in depths of up to 70 feet. A major consideration was the fact that the only way to leave the site was over a canyon rim that rises to an altitude over 9,000 feet from the deep gorge of the Black Canyon of the Gunnison River. As a result, after all the necessary computations were made to prevent any decompression complications, it was determined that each diver could stay down only 20 minutes. Each diver would have to wait 2 to 3 hours between dives. In addition, the divers had to wait 2½ hours after their last dive to travel over the canyon rim.

Over 20,000 hours without a diving accident.

Of significant importance is that operations at Reclamation structures facilities do not always have to be halted during the dives. It is estimated that millions of dollars have been saved because of minimum project shutdown. Interruption of power and water service has been minimal, and preventative maintenance due to early underwater detection of possible problems has kept operation costs down.

The ultimate goal of the diving teams throughout the Bureau of Reclamation is to do an efficient, thorough job in a safe manner. That goal is being accomplished. Since that first team was formed in 1964, it is estimated that Reclamation divers have logged over 20,000 hours on the job—without a single diving accident.

Introducing Orrin Ferris

An interview with Deputy Commissioner Orrin Ferris, conducted by Tom Hughes

Q. Mr. Ferris, would you give us a brief look at your educational and professional background?
A. I am a graduate of Montana State University at Bozeman. I have bachelor degrees in Industrial Arts and Technology, and Civil Engineering, and a master's degree in Civil Engineering.

I started my professional career in civil engineering with the Soil Conservation Service before graduating from college. After graduation, I continued with the Soil Conservation Service. I spent 2 years working in Gallatin and Park Counties area of Montana, on water and soil conservation projects. Then, I accepted a position as chief of the engineering division of the Montana State Water Resources Board. Two years later that became the Water Resources Division of the new Department of Natural Resources and Conservation, and my title changed to chief of the Engineering Bureau.

In 1974, I took the position of Administrator of the Water Resources Division in the Montana Department of Natural Resources and Conservation, which brings me up to date.
Q. What was the appeal of joining Federal Service? What brought you to Washington, D.C.?
A. I had worked for both the Federal and state governments before I accepted this position. And, I don't really have a preference between the two. The real reasons for accepting the Reclamation position were the content and purpose of the job, and the career development and growth potential for me.
Q. Montana is a Reclamation State. In your experiences, did you find that the Reclamation program and accomplishments were common knowledge or was there a lack of awareness about Reclamation operations?
A. Of course, there is always the confusion among individuals who lump all government and associations together, and can't identify one from the other. But, anyone who was informed in water and land resources development certainly was aware of Reclamation and its programs and activities. I would say that Reclamation work is well known in Montana.
Q. How do you see your responsibilities as Deputy Commissioner of Reclamation?
A. The precise working arrangements are evolving as time goes on, but basically the Deputy position is designated to act in behalf of the Commissioner when his workload or his travel schedule do not permit him to be available.

One refinement, so far, is that I have been assigned primary responsibility in three distinct areas in which I will be taking more of the lead than would otherwise be the case. These are the Washington offices of Equal Opportunity, Environmental Affairs, and the new Office of Contract Oversight and Policy.
Q. Can you give us an idea of what your goals might be within the Bureau of Reclamation?

Tom Hughes, Public Information Specialist, Office of Public Affairs, Washington, D.C.

Orrin Ferris.

A. My entire professional career has been with a government agency. My personal goals, the areas in which I want to achieve, are to help carry out the basic laws that authorize the actions of the agency, and to make the operation of the Bureau of Reclamation as smooth as possible by trying to resolve any internal organizational, personnel, and other types of problems that tend to lessen the effectiveness of an organization. Every organization has those kinds of problems. The more successful ones are the ones which can solve those problems quickly, and get on with the real job of providing their services to the American people.

In short, what I want to see is the Bureau of Reclamation doing the best job it can, based on what it has been asked to do and funded to do.

Q. Reclamation is undergoing change—change that is essential to the Bureau. How do you perceive this change and what will Reclamation's mission be?

A. Life itself, as well as American society, is in a constant state of change—it always has been. Every organization needs to be aware of those changes, be willing to keep in step and most of all, be responsive. The better that we can adapt, the better job we will do.

Q. Do you think the Bureau of Reclamation will be recognizable to an employee in 5 or 10 years hence after some of these changes have taken place?

A. That is asking for a prediction of what we may be asked to do by the Executive Branch and the Congress. Certainly I see some changes in direction. All natural resource agencies have already been through considerable change during the last few years and I think that changes will continue to occur.

Whether or not employees will be able to recognize the Bureau in 10 years hence—I believe they will, but they will also recognize a number of changes in direction as well as in the level of activity. The resource that we are developing is not unlimited and much of that resource has been developed in the West. The most economical sites have already been developed so the problem of future development will become increasingly difficult.

I am sure that new missions will be given to the Bureau of Reclamation as time passes.

Q. You were a member of the Peace Corps in Ecuador. Can you tell us what you did?

A. I was part of a group designed to provide community development assistance to small villages in Ecuador. My wife has

---

Photography by Charles U. Carter, Washington, D.C.

had elementary education training, so we were a team. The village was isolated in the jungle of Ecuador in the Amazon drainage area. It was an area that is populated by the Jivaro Indians and has only been colonized by other Ecuadorians during the past 30 years. In fact, our town looked very much like an Old West movie set. I worked on roads and bridges, hydroelectric facilities, and, although the level of development was fairly primitive, it gave me a real understanding of basic engineering and how to get something accomplished within an institutional structure. I even got involved in the school room situation to some extent. Aside from these "official" activities, just surviving in that kind of economy and those living conditions provided us with opportunity to help our neighbors with home improvement and health information.

Q. How did this experience affect you?

A. It has had a profound effect on our lifestyle. When we first came back, everything appeared to be covered with concrete and asphalt which of course is an exaggeration, but that was the impression. The hardest adjustment was the pace of life. We kid about the rat race, but compared to our experience in Ecuador we are really in a race. If anything, it has taught us to adjust our lifestyle so that we are not caught up in the rat race as much as we might be. And that is a positive effect.

Q. Has there been much of a problem for your family being uprooted from the quiet expanse of Montana and moving to a large city like Washington, D.C.?

A. The adjustments have not been nearly as great as we might have guessed. We worked hard at making the move as smooth as possible. We were able to locate and be ready to start school the same time I started to work. Washington is an interesting place to live with things to do that we could not do in Montana. My children (Lora 11, Kent 9, and Chad 7) have had only one complaint about their schools. They said the teachers do not exercise enough discipline; it makes it hard for them to study. I suspect in a few months I won't hear that again. Otherwise, they are well satisfied. In fact, there are more programs and activities available to them and they seem to be fitting in quite well.

Young engineers compete...

IN SEARCH OF THE BEST BRIDGE DESIGN

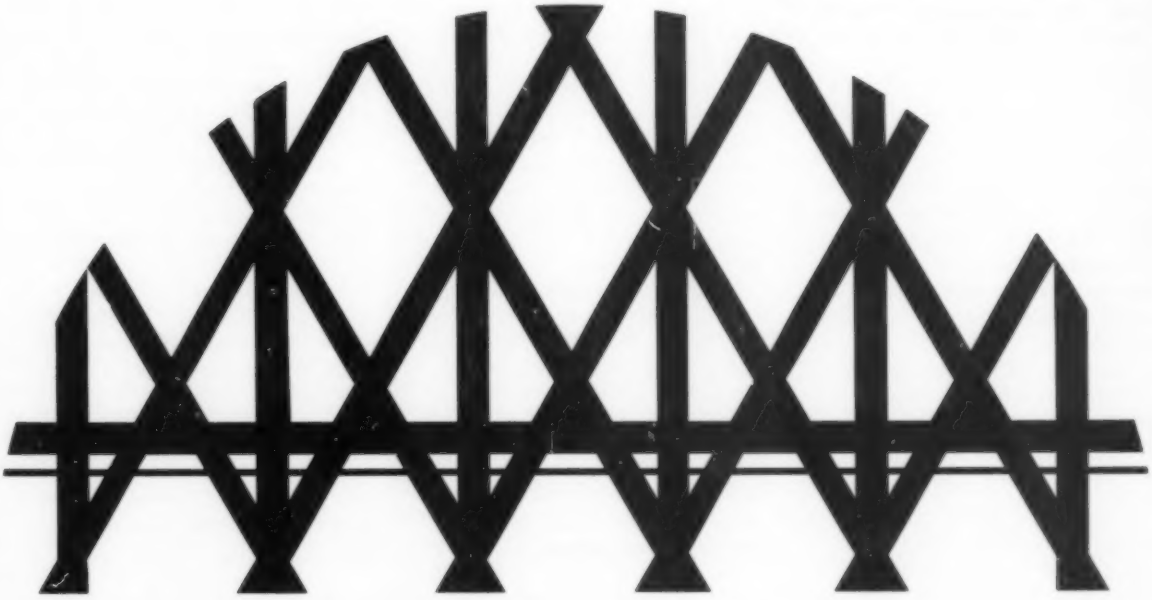
by Hunter Holloway

Take a sliver of balsa wood; saw, sand, and whittle it into shapes; and then glue all the pieces together. The end product might resemble a pile of wooden matches or an abstract art sculpture.

But ... if it is in the hands of a potential engineer, it could have the makings of a well designed bridge. And ... if the parts are carefully planned and placed with precision, it is possible the model bridge could weigh less than an ounce, and support 6,387 times its own weight.

Rick McDonald did just that. On the morning of February 10, 1979, his model bridge took first place honors at the 12th Annual Model Bridge Building Contest. The 17-year-old senior from Denver's John F. Kennedy High School was one of several hundred students from 28 Colorado high schools to participate in the contest.

Hunter Holloway, Media Relations Officer, Public Affairs Service Center, Denver, Colo.



The contest, sponsored by the Bureau of Reclamation and the Professional Engineers of Colorado (PEC) is held annually at Reclamation's Engineering and Research Laboratories at the Denver Federal Center. The students represent small, rural communities as well as Colorado's large metropolitan high schools. The students compete with each other through the early winter to reach the Denver finals.

In Rick's case, he was among 25 students competing from John F. Kennedy High School. The physics teacher, Ron Baldwin, gave the students hints on what designs he believed might have a chance. After several weeks of experimenting, the class went to a Martin-Marietta aerospace plant near the school, and tried their ideas and handiwork on the plant's testing machine. Of all the model bridges designed by the class, those built by Rick, Tom Hail, and Fred Ard, appeared to be the strongest and the lightest.

Contest rules mandate that bridge models must be no longer than 300 millimeters (a little less than 12 inches), and weigh no more than 60 grams (approximately 2 ounces). So, weight of the finished model is a prime competitive factor.

The Colorado winners are determined by an efficiency number—the maximum load supported by the bridge, divided by its weight. The team scores are the sum of the efficiency numbers earned by three team members.

The Kennedy students reasoned that although featherweight bridges might not take fantastic loads, they may be far more efficient than their heavier

Fred Ard, Tom Hall, and Rick McDonald make last minute adjustments to their entries as teacher Ron Baldwin watches.

counterparts. The reasoning was accurate, but the students at the competing schools were thinking along the same lines.

Rick, Tom, and Fred, along with their teacher, checked into the contest early Saturday morning and watched their competition go to the mat with a Reclamation testing machine capable of exerting 120,000 pounds of pressure—more than enough to return the models to their original state of pieces and slivers.

PEC members managed the contest and checked each entry to make certain it conformed to specifications. Reclamation volunteers operated the weighing scales, the testing machine, a computer, and a closed-circuit television system.

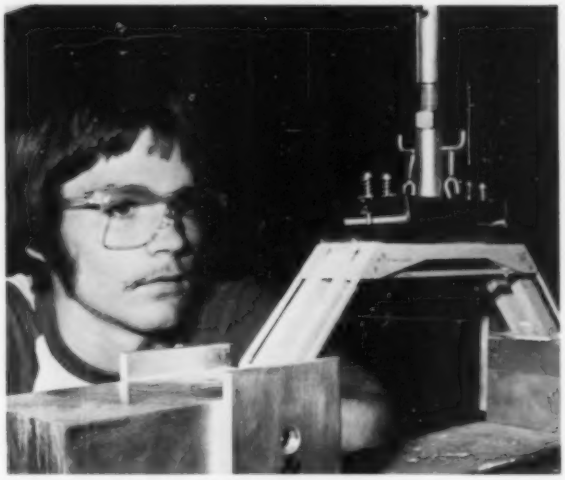
Teachers, students, and parents watched as each contestant gently placed his handiwork below the machine only to see the bridge crumble and register a pressure reading on a nearby instrument. Through the computer link, the final efficiency factor was calculated immediately and was visible on the closed circuit televisions placed around the test area.

The team from Kennedy High School, nervous as larger and larger numbers appeared on the screens, went to work carefully sanding and smoothing excess milligrams from their bridges. Ron Baldwin, their teacher, talked physics to the young men, assuring them that their models were the best, that the designs would hold up longer than the others, and that he was certain that this was Kennedy's year to take its share of the trophies provided by the Professional Engineers of Colorado.

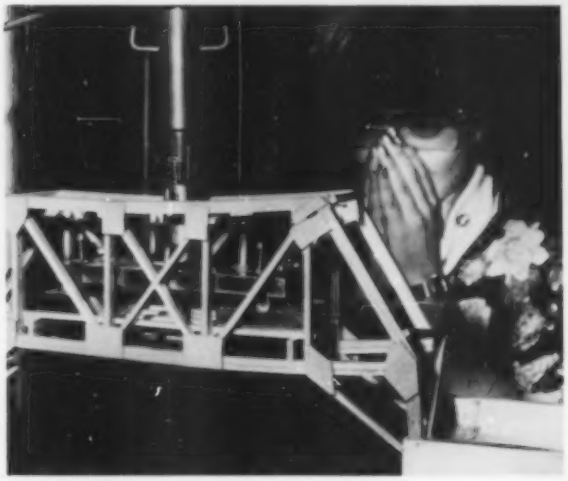
After all, Baldwin reasoned, Kennedy had taken second place the two previous years, and "We're tired of being the bridesmaid."

Fred was first. Like the others, he checked in and had his bridge weighed and measured to meet the contest requirements. He stepped up to the line and was identified by an engineer over the loudspeaker.

At the testing machine, Fred set his model in place, donned a pair of safety glasses, and



Pressure is brought to bear on Rick's bridge.



Tensions increase as entries tumble.

nodded to the machine operator. The two pressure pads descended slowly, paused, and continued down. In about five seconds the model began to yield. With the balsa wood emitting tiny squeaks and a miniature dust cloud, the bridge finally collapsed and the machine stopped.

On the screen, there appeared the numbers: 22.94 grams (bridge weight) ... 193 lbs. (the pressure withstood) ... and 3816 (the efficiency rating).

Tom Hail came next. His bridge model tested out at 19.05 grams, withstanding 141 lbs., for an efficiency rating of 3357.

Then it was Rick's turn. He watched intently as the pressure pads pressed on his model. The instrument climbed to 100 lbs., 200, 300, and 350. Finally at 355 lbs., the slowly yielding crack at one end gave way and the pressure stopped. The computer printed out: 25.21 grams as the model's weight, 355 lbs. of pressure with an efficiency rating of 6387.

Rick was in first place, with Tom and Fred placing in the top 10. They had withstood the competition from 64 other finalists.

In effect, Rick had designed and built a bridge weighing about the same as five nickels. Yet, it would support a column of nickels nearly 8 feet high ... an efficiency unheard of in highway bridge construction, and found today only in the most sophisticated industries.

"That does it," Baldwin said as Rick returned from the testing machine, "Now all we have to worry about is Cherry Creek," a school having a long rivalry with Kennedy.

A half hour later, Cherry Creek High School's team, using a different design, proved to be no threat.

The contest ended at noon, and Kennedy was on top, far ahead of second-place George Washington High School of Denver and third place Delta High School from western Colorado.

Rick was presented his trophy for first place, followed by Tom Downs of George Washington more than 1200 efficiency points behind. Doug Stoner of Wesson High School in Colorado Springs was third. Fred placed seventh, and Tom ninth.

You can bet Kennedy's physics teacher Ron Baldwin will be back next year, but he will have a new group of potential engineers. Rick, Tom, and Fred are seniors and are college-bound.

Photographs by Bob Pauline, Bureau Photographic Coordinator, Public Affairs Service Center, and Wayne Lambert, Scientific and Technical Photographer, Engineering and Research Center, Denver, Colo.

WINTER WONDER-LAND

by Vern Jetley

The 1978-79 winter has draped a heavy mantle of snow over southwestern Colorado's majestic San Juan Mountains, turning the rugged terrain into a tranquil winter wonderland. Half-buried remnants of old mining camps add to the beauty - and mystery - of the snow-covered region.

These photographs were taken by Vern Jetley, regional photographer in the Upper Colorado Region.

Water

Quiz

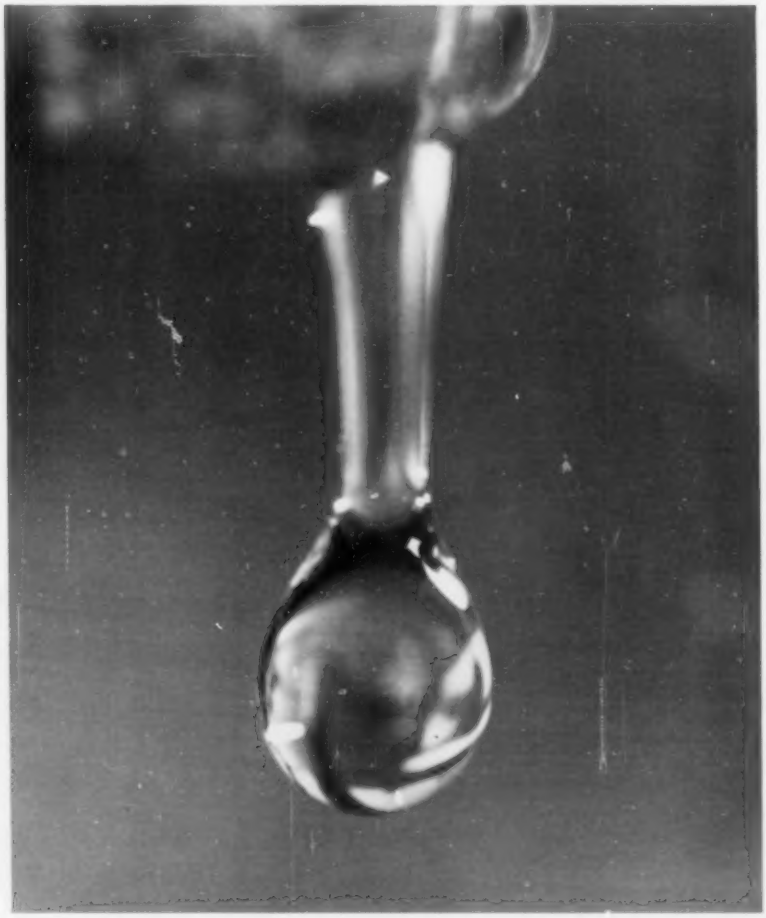
1. The world's annual rainfall is about _____ tons of water.
a. 480,000,000,000,000
b. 200,000,000,000,000
c. 550,000,000,000,000

2. Human blood is _____ percent water.
a. 60 b. 90 c. 50

3. When did the Federal Government establish the first binding national quality standards for drinking water?
a. 1951 b. 1975 c. 1925

4. Detergents that contain water softeners help reduce bacteria and other microbes, and materially contribute to minimizing cross infection. True or False?

Answers to Water Quiz on page 32



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A series of brochures covering Bureau of Reclamation activities in the 17 Western States was recently published. Each of the 17 brochures briefly discusses a specific State and includes the history of water development, benefits from Reclamation projects, the future of Reclamation activities, and a summary of Reclamation projects within that State.

Brochures of any individual State or a full set of 17 are available, without charge, from the Engineering and Research Center, Code 922, P.O. Box 25007, Denver Federal Center, Denver, CO 80225. Bureau of Reclamation regional offices also have brochures for those States that are either completely or partially within their region.

Answers to Water Quiz

1. a. 480 trillion tons
2. b. 90 percent
3. b. 1975
4. True

Photograph by Howard Paul, photographer, Engineering and Research Center, Denver

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